CONSERVATION OF ANIMAL BREEDS IN GENERAL

Conservation des races animales en général

Allgemeines über die Erhältung von Tierrassen

K. MAIJALA *

Introduction

Conservation of genetic variation may still be considered quite a controversial problem, although it has been discussed in several occasions during the last 10-15 years (*e. g.* Edwards, 1959; Hodgson, 1961; Scossiroli, 1964; Van Albada, 1964; Menzi, 1966; F. A. O., 1966; Maijala, 1970). There are at least the following conflicts:

— need of fast genetic progress at present *vs.* possibilities of progress in the future;
— immediate economy *vs.* possible uncertain profits in the future;
— needs of the society of abundance *vs.* needs of starving societies;
— needs of times of peace *vs.* needs of wartimes or crises;
— optimistic *vs.* pessimistic views of the future of mankind or of the possibilities of animal breeding.

Disagreement between scientists is understandable on the basis of their previous experience, of the particular species they are working with, and of how far ahead they are inclined to look. Even the age of scientist may play some role here.

The problem is most actual in the species in which the natural reproduction rate (poultry) or modern techniques (A. I. in cattle) make it possible to spread out selected material very rapidly, *i. e.* heavy concentration. Another important group consists of species or breeds which are approaching extinction.

The purpose of the present paper is to discuss some general aspects as well as reasons and methods of gene conservation.

* Institute of Animal Breeding, Agricultural Research Centre, Box 18, Tikkurila 01301, Finland.

Arguments for conservation

The motives of adopting special measures for preventing loss of genetic variation were discussed at rather great length in my earlier paper (Maijala, 1970), but a repetition of the main arguments may be well-founded in this connection.

a) *Examples of gene losses in the past*

Past experiences are in many cases useful indications of the importance of a problem. With regard to gene losses the experiences can be divided into two main groups: losses of entire populations (species, breeds, strains), and losses of genes within populations. Losses of *breeds* have been common during the last 50-100 years in many parts of the world. Many local and some international breeds have had to give way to other breeds, considered to be superior to them. The following examples of vanished or rapidly losing breeds were given in my earlier paper:

- Finnish native cattle (Finncattle)
    - North-Finnish (white) type practically disappeared,
    - East-Finnish (colour-sided) rapidly disappearing,
    - West-Finnish (red) type losing ground for bigger-sized breeds.
- Finnish Landrace sheep (Finnsheep), population decreased from 1.2 mill. head in 1950 to 0.15 mill. in 1967.
- Finnish native hen might be entirely lost.
- Swedish Polled Cattle, situation similar to that of Finncattle.
- Norwegian cattle breeds: ca. 30 breeds in 1930, now 2-3 left.
- British cattle breeds: number halved since 1900.
- French hens: 19 local breeds near extinction (Boyer, 1964).
- Dutch hens: situation almost the same as in France (Van Albada, 1964).

During the last five years the share of Finncattle of the recorded cows has decreased by ca. 2 %-units per year and is now 14 %. The decrease is enchanced by the fact that very few breeding herds are any longer producing bulls of this breed. In Sweden, less than 2 % of the recorded cows now belong to the Polled Cattle.

The number of Finnish horses is nowadays decreasing by ca. 10 000 heads a year and is now about 44 000. Of the Finnish goats only ca. 1 000 animals are estimated to be left.

In West-Germany, five of eight swine breeds have disappeared between 1952 and 1970, and two of the remaining ones have considerably decreased in frequency (Glodek, 1972).

Disappearance of breeds might be acceptable in case it is based on factual evidence of their inferiority in all circumstances. It is obvious, however, that the choice of breed has often been based on rather superficial knowledge, biassed by many environmental factors, since objective, comparable information of the merits of different breeds is scarce even now. In case objective information can be found it may be very one-sided, concerning only a couple of economic traits.

The way of measuring these traits may not always be the best one. For example, milk yield is usually expressed per animal, without considering the maintenance feed requirements or other cost items. Measuring the yield per feed unit, per live weight Kg, per working hour or per hectar might have led to different conclusions with regard to relative usefulness of breeds. Considering also the kind of feed available or other production conditions might have been important in some cases. Similar one-sidedness has sometimes occurred in the evaluation of breeds for meat production: attention has been paid only to growth rate or muscularity, although the efficiency of production depends also on fertility and maintenance requirements.

Some previously unknown breeds have already proved their usefulness for special purposes. As examples may be mentioned the fastgrowing Charolais cattle, the muscular Cornish game-cock or Belgian Landrace swine, the leukosis-resistant Fayoumi hen, and the fertile Finnsheep.

A cautious displacement of breeds can be justified also on the ground that a given quantitative trait may partly be determined by different sets of genes in two breeds. For example, the share of common alleles of the B blood group system of West-Finnish and Ayrshire bulls was only 19 % (MAIJALA, 1970). If this dissimilarity even only partly reflects differences in the frequency of «production genes», it is a pity to lose all the Finncattle genes.

Losses of *strains* within poultry breeds have occurred, especially during the last two decades, due to the expansion of very few hybrid firms at the cost of many others. The number of strains may not have decreased as rapidly as that of breeders, but this does not necessarily mean a restraint in gene losses, if the new strains are only sub-strains of the surviving breeders. It has been claimed that it is difficult to find new successful strains, but JAAP (1966), observed that alleles carried by slowly growing egg-production strains were useful in improving the growth rate of broilers. This supports the above hypothesis that a quantitative trait may be determined by different genes in different populations. Combining two or several such strains would thus give a good basis for selection. It is reasonable to assume that a loss of a strain with exceptional gene material is more harmful than losing a strain with an exceptional frequency of genes found in the remaining strains (OROZCO, 1964).

In Finland, the number of egg-laying strains has been halved to about 25 during the last 10 years. It is obvious that this is partly due to the establishment of Random Sample Testing in 1962. Because of the small sample size and other imperfections in the testing techniques it is very likely that some useful strains have been lost. Such a loss may have been caused also by the fact that a breeder has had only one good strain and no proper counterpart for its crossing in order to successfully compete in R. S. tests.

b) *Gene losses within populations*

There are two well-known forces causing decay of genetic variability within populations, namely selection and random drift (chance).

Selection should reduce genetic variability, since the aim is to increase the frequency of «good» genes at the cost of «bad» genes. Many workers have, in fact, experienced a «ceiling» in their selection experiments with laboratory animals or poultry (FALCONER, 1955; CLAYTON and ROBERTSON, 1957), but the reason has in most cases been found from elsewhere than from decay of genetic variability (DICKERSON, 1955; ROBERTSON, 1955). Often it has been difficult to see any decrease in the phenotypic variability, even though the mean performance has changed considerably. Yet LERNER and DONALD (1966) consider that «gains in selection are always achieved at the cost of reducing variance».

Interesting hints can be found from some simulation studies. YOUNG (1966), for example, showed that the decay of variance can be very rapid, if one selects strongly for a trait with a high heritability. Even a medium heritability led to a rapid loss of additive variance, when selection was very strong. The losses of genes caused by directional selection are thus obviously worth considering.

Chance can be an important cause of gene losses in small populations. These losses affect the «good» and «bad» genes with equal probability and are thus undirectional. The losses can be predicted with the aid of the concept of effective population size (N_e) introduced by WRIGHT (1931). Considering that the loss of heterozygosity per generation is approximately proportional to $1/2\,N_e$ the critical values of N_e lie between 50 and 10. In the former case the loss is only 1.00 %/generation, but in the latter 5 %. The corresponding numbers of sires per generation in cattle are 12.5 and 2.5. The general use of frozen semen has made it possible to approach these values in many countries. The actual coefficient of inbreeding, which usually has varied between 0.2 and 0.8 % per generation in various cattle breeds, is not very suitable for measuring the gene losses because of the intentional avoidance of inbreeding in A. I. operations. Instead, one should use the expected inbreeding coefficient, based on the average coefficient of relationship, or the sum of squared allelic frequencies of *e. g.* the B blood group system in cattle (MAIJALA and LINDSTRÖM, 1966). The expected coefficients can in some cases be 2-3 times bigger than the actual ones.

The decay of variability caused by random drift is usually somewhat slower than that caused by directional selection (ROBERTSON, 1960), but the relative importance of these forces depends, of course, on the actual situation, particularly on the intensity of selection and effective population size.

c) *Changing environmental conditions*

An essential part of the development work in animal production consists of improvements in the external production conditions, and changes in this field are highly probable in the future. The possible changes of environment can be grouped as follows:

- changes in feeding (new economic feedstuffs, changed relative proportions because of increased intensity, etc.);
- new diseases (*e. g.* viruses for which it is difficult to find effective medicines);
- developments in housing (regulation of temperature, moisture, light, etc.);
- changes in management (milking machines, higher animal densities, cages, sex sorting, out-of-season production, etc.).

The necessity of taking these changes into account in breeding work depends on the existence and magnitude of heredity x environment interactions. The importance of these is still a subject of considerable controversy among scientists, since there are both negative and positive experimental results, but obviously the importance varies with the species, the trait and the diversity of environment. In proportion as there have been experiments with greatly varying and well-defined environments, more and more positive evidence has been accumulating during recent years, especially in poultry (MERAT, 1968). Since specialization of environments is a likely direction of development, it appears reasonable to maintain enough variability for fitting animals for special environments. This may in some cases be cheaper than to fit the environment for special animals.

d) *Changing demands for products*

Because of the ample past experiences it may be easy to agree as to the need of maintaining a moderate amount of variation in our animal populations, in order to be able to cope with future changes, caused *e. g.* by the following factors:

— new knowledge in the field of human nutrition;
— increasing standard of living;
— new fashions in clothing or eating;
— increased quality requirements regarding conventional products;
— need of decreasing the production costs and prices;
— need of greater quantities, in order to combat hunger;
— need of compensating exhausted natural reserves of some materials;
— need of finding new ways of utilizing agricultural plant products in case of surplus problems.

The recent protein and oil crises are examples of radical changes in the world market which may have an effect on the demand and price of certain animal products.

e) *Other aspects*

Several additional aspects deserve attention in discussing the need of gene conservation, for example the following:

— experiences obtained in plant breeding;
— existence of many unexamined breeds and strains in the world;
— need of improving the utilization of land;
— possibility of utilizing hybrid vigor;
— difficulty of creating new useful genetic variation in animals, and the time needed for testing its usefulness.

LERNER and DONALD (1966) considered that every generation has a duty to look after the maintenance of genetic variation. It may be reasonable to add that every country has the moral obligation to conserve its national populations of animals.

Arguments against conservation

The heaviest argument against special conservation actions is the cost side, especially in relation to the possible profits, which are very difficult to estimate. In addition, the gains may become harvested only during the next human generation. Thus, an animal geneticist, who worries about the conservation of genes, can be considered unrealistic and therefore trust in him can be lost even in presentday matters. Another geneticist, who doesn't vorry at all, can for his part be relatively sure that he doesn't need to answer for the consequences at the time these become apparent. The same reasoning applies to entire breeding organizations: they would very much like to see their competitors taking care of this matter.

Another argument used against conservation is that the general genetic level of the conserved material will be left behind at the time its special genes are required, so that its effect on the total economic value is negative.

However, there are many alternative ways of gene conservation, and some of these may be cheap enough to be seriously considered. The costs caused by the conservation itself can be lowered by other uses of the method, and the existence of proper safeguards may make it possible to take more courageous and faster steps in the breeding of to-day. This may pay the conservation costs manifoldly.

Possible conservation policies

It may be agreed that there are too many breeds and strains of different species in the world to be economically conserved for possible future needs. The first step in any conservation scheme is therefore to decide which populations are worth of conserving.

a) *Testing*

Especially those populations which are approaching extinction should be investigated as soon and as thoroughly as possible in relation to each other and to the prevailing breeds. A thorough testing of all populations is also very expensive, and hence one has to find an optimum between testing costs on one hand and conservation costs and profits on the other hand. The decision concerning the populations to be conserved may thus be best to make stepwise:

1) Inventory of available stocks and their subjective evaluation on the basis of collected information, taking into account the environment in which the stock has been performing.

2) Planned collection of special complementary information of the interesting populations, *e. g.* with the aid of field testing.

3) Comparison of the most promising populations in a common environment, if possible, or by using common control stocks.

The results of the comparisons can be utilized not only for an absolute decision of the stocks to be conserved but also for deciding how completely (and expensively) each stock is to be conserved. There may exist a need of conserving some populations provisionally until the testing results are available, since the testing may take a long time. Testing and conservation can thus not be entirely separated from each other.

b) *Methods of conservation*

There are at least the following alternatives for conservation:

1) maintenance of pure breeds or strains;
2) establishment of one or several gene pools;
3) banks for frozen semen, embryos or gonadal tissues;
4) cautious selection minimizing gene losses;
5) reliance on other countries or organizations.

The last alternative is, of course, only a way of proceeding and not a conservation method. The choice between the other alternatives depends partly on the size and reproductive ability of the species, on the kind of traits each population possesses, and on the purposes of its preservation. It may be reasonable to apply several methods simultaneously for the same population. For example, conservation of a cattle breed as pure can be performed with considerably smaller numbers of animals, if a many-sided semen bank is available for producing every new generation of females. Every female can thus be sired by different male. Fifty females would obviously conserve the breed reasonably well in this case. Maintenance of gene pools is similarly facilitated by a good collection of frozen semen. This cheap and easy way of conservation cannot, of course, yet be applied to many species, but besides cattle it should be possible in horses, sheep and goats, perhaps also in swine. The need for maintaining living populations will decrease as soon as freezing of embryos becomes possible in practice.

The costs are, indeed, no more any excuse for not establishing a gene bank. In Finland, where all bull semen is in the form of pellets, the preparation cost has been estimated to be about 0:10 Fmk per dose and the preservation cost (amortization and interest of container+ liquid nitrogen) less than 0:01 Fmk/dose/year (LINDSTRÖM, 1972). The pellets can most practically be conserved in tubes, and so one tube of 200-250 pellets for each bull which now has frozen semen in store would be a proper solution for a gene bank for both Finncattle and Finnish Ayrshire. It is highly desirable that there is a thorough and many-sided «ware description» for each tube, based on observations on the bulls themselves or their progeny.

It would be well-founded for the A. I. societies (six stations in Finland) to take care of the conservation, since the costs would be covered by even a very small increase in the rate of genetic progress (less than 0.1 %/year). The storage at several stations would also be a safeguard against accidents. However, a small subsidy from the state would be reasonable to stimulate conservation in each society, and in order to get regular information for a central register. An annual subsidy of 3 000 Fmk would obviously cover all maintenance costs in Finland. With the same money some state institute could also undertake the task of conservation, for which a container costing about 12 000 Fmk (1 200 £) would be sufficient. In addition to 400-500 tubes of bull semen, at least 100 tubes could be placed in the same container for each of three other species (horse, sheep, goat).

In poultry and other species in which frozen semen banks are not yet applicable, one has to decide between conservation of pure strains and establishment of gene pools. Obviously, both methods have to be used, depending on the particular situation. Breeds or strains which have some special traits well developed, deserve to be kept as pure, while an amalgamation into a gene pool may be appropriate for some other strains. The possibilities of utilizing non-additive inheritance speak in favour of pure strain conservation instead of gene pools. However, strains with similar special traits might be combined to a common gene pool. The principles to be applied in establishing and maintaining gene pools were discussed *a. o.* by Jaap (1964). According to him it is better not to combine more than 2-3 populations into a pool.

The costs of maintaining gene pools can be lowered by finding various economic uses for the population. One possibility is to use it as a random bred control population in Random Sample tests or other breeding experiments, or as an animal material in feeding trials. Another possibility is to collaborate with zoological gardens in conserving special breeds, and a third possibility to combine the conservation with other leisure time interests as *e. g.* with so-called fancy-breeding. Even rather short conservation periods (5-10 years) could be useful in many cases.

SUMMARY

Some general aspects as well as reasons and methods of gene conservation were discussed. As arguments for conservation were mentioned several examples of losses or nearby losses of entire breeds or strains, within-population losses due to selection and random drift, changes of the environmental production conditions, changes in the demand of various animal products, and some miscellaneous factors. The costs of conservation and the doubtful usefulness of the conserved populations in future were presented as arguments against special conservation actions.

In discussing possible conservation policies, the importance of proper testing as the first step was stressed. In regard to the methods of conservation, main attention was paid to frozen semen banks, which now can be established and maintained very cheaply at least in cattle. Establishment of gene pools or conservation of pure breeds or strains in poultry were briefly discussed, as well as the possibilities of lowering the maintenance costs.

RESUME

Quelques aspects généraux, de même que raisons et méthodes de la conservation des gènes ont été discutés. Comme arguments pour la conservation ont été mentionnés plusieurs examples des disparutions ou quasi-disparutions des races et lignes entières, des disparutions dans la population, dues à la sélection ou à la dérive aléatoire, aux changements des conditions extérieures de production, aux changements dans la demande de différents produits animaux, et aux quelques facteurs diverses. Les coûts de la conservation et la discutable profitabilité dans l'avenir des populations conservées ont été présentés comme arguments contre des actions spéciales de conservation.

En discutant l'éventuel projet de conservation, l'importance du testing proprement dit comme premier pas, a été soulignée. A sujet des methodes de conservation, surtout en matière du bétail l'attention principale a été attachée aux banques de sperme gélée, lesquelles, à présent, peuvent être établies et maintenues aux

coûts très bas. Quant à la volaille, l'établissement des lignées polyalléliques ou la conservation des races ou des lignes pures, ont été brièvement discutés, ainsi que les possibilités de baisser les coûts de maintenance.

ZUSAMMENFASSUNG

Die allgemeinen Aspekte wie auch die Gründe und die Methoden der Genenkonservierung sind diskutiert worden. Als Argumente der Konservierung sind viele Beispiele von dem ganzen oder teilweisen Verlust der Rassen oder Linien erwähnt worden. Man hat auch den Verlust innerhalb der Population erwähnt, der auf Anlass von der Selektion und unregelmässigen Ausnahmen entstanden ist, sowie Anderungen der äusserlichen Produktionsumstände, Anderungen in der Nachfrage der verschiedenen Tierprodukte und einige verschiedene Faktoren. Die Kosten der Konservierung und der Zweifel an der Brauchbarkeit der konservierten Population in der Zukunft sind als Argumente gegen die Konservierungs-aktionen vorgestellt worden.

In der Diskussion von den möglichen Konservierungspolitik hat man die Bedeutung des Testen der Populationen als erster Schritt betont. Wenn man die verschiedenen Konservierungsmethoden betrachtet, hat man die Hauptachtung an die Gefriersamenbanken gerichtet, die auch mit relativ wenigen Kosten gegründet und aufgehalten werden können. Die Gründung der Genenpoole oder die Konservierung von reinen Rassen oder Linien bei dem Geflügel wie auch die Möglichkeiten von der Verminderung der Aufenthaltkosten sind kurz diskutiert worden.

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